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ROADBANK STABILIZATION AT LOW COST <sup>6.31</sup>

A Progress Report

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## C O N T E N T S

	Page
Planting without preliminary stabilization . . . . .	2
Mulching as a minimum requirement. . . . .	2
Staked weed mulches . . . . .	4
Brush and litter mulches. . . . .	6
Illustrations:	
How stakes are set on banks . . . . .	8
How weed mulches are applied. . . . .	8
The weed mulched bank completed . . . . .	10
Natural vegetation appears the first year . . . . .	10
Detail of brush and litter mulch. . . . .	12
Detail of loosened bank and topsoil application . . . . .	12
Example of planting without mulching on steep bank. . . . .	14
Example of mulching without staking on steep bank . . . . .	14
Procedures for better roadbank stabilization . . . . .	16
Preparation of banks. . . . .	16
Seeding . . . . .	16
Transplanting . . . . .	17
Topsoil dressings . . . . .	18
Fertilizing mulched banks . . . . .	18
Costs. . . . .	19
Suggestions for improvement of mulching practices. . . . .	20



## ROADBANK STABILIZATION AT LOW COST

Extensive construction of new roads in the Southern Appalachian region has followed public demand not only for better communication and marketing routes but also for easy access to the higher mountain recreational areas. Thousands of miles of new road construction and improvement have been made during the emergency programs of the past seven years. Much of this construction has necessitated large cuts and fills. Unavoidable as they were in the road construction, these extensive exposures of bare soil soon attracted much unfavorable comment. Motorists protested against the unattractiveness of the roadside. Fishermen and those needing clear water for domestic and commercial purposes reported that the streams were muddied by soil washing from road cuts and fills. Road engineers found that sloughing of material from the roadbanks contributed to increased maintenance costs. It became obvious that some form of roadbank stabilization would be necessary to keep the roadsides more attractive, to prevent soil from eroding into the streams, and to reduce the cost of road maintenance.

The Appalachian Forest Experiment Station began work on this problem five and a half years ago in the spring of 1934. It seemed obvious from the start that the only practical answer to this problem of anchoring soil was to hasten the natural revegetation of the exposed slopes. The intervening years have not brought forth any better solution.

But getting vegetation established on all cut and fill slopes is not a simple task. In the first place, the raw, infertile, newly exposed banks are exceedingly poor seedbeds for plants of any description. Many slopes had infertile soil and insufficient moisture, and were fully exposed to the constant drying of sun and wind. And, among other unfavorable factors, was the actual physical instability of the soil resulting from alternate freezing and thawing with consequent uprooting of plants that had started. The soil loosened by frost action was easily washed off the bank by rains.

In some places roadbanks have reseeded naturally and with remarkable promptness. If the soil is fertile, if adequate moisture is present throughout the growing season, and if the banks do not erode too severely, natural reseeding without special treatment by road engineers can be expected. But most large cut banks and some fills have not revegetated naturally and are not likely to do so for many years to come.



## PLANTING WITHOUT PRELIMINARY STABILIZATION

Early recognition by road engineers of the fact that natural vegetation comes in slowly on new banks has resulted in extensive plantings and seedings to obtain stabilization. Some cut banks were given a light top dressing of rich soil on the smooth slopes and hand-sown to grass, but frequently where this was done hard rains washed the unprotected dressing and grass seed into the ditches even before germination had taken place. Other slopes were partially covered with long strips of grass sod set in contour furrows, but the sod strips were often undermined by frost action and erosion. "Pot hole" and trench plantings of honeysuckle root clumps, coralberry, and other vines and bushes were made on a large scale. The results were sometimes extremely good but more often extremely poor. The root clumps grew poorly or died, or were washed out after being undermined by erosion. In general, the strip sodding and the bareground seeding proved impractical on cuts, and the pot hole plantings succeeded only where soil fertility and moisture, on north slopes for example, enabled the plants to gain a foothold before they were washed out. Moreover, all of these methods were found to be too expensive to permit treating the many hundreds of miles of roads needing bank stabilization.

What was needed was a method which would assist nature in the reseeding job -- a method which would be simple to apply, reasonably certain as to results, and inexpensive.

## MULCHING AS A MINIMUM REQUIREMENT

There is no need to describe here the various experiments which led to the conclusion that the simplest, cheapest, and only sure method was first to reduce mechanical action to a minimum by rounding off tops of slopes, reducing steepness of slopes as much as possible, and minimizing frost heaving; and second, to provide an adequate seedbed including both soil fertility and moisture. Except for reduction in slope and loosening and rounding off tops of banks, these requirements can be met by applying a mulch of weeds, straw, grass, etc., to the raw slopes. Do this -- and do it properly -- and in nearly every instance Nature will do the rest. Mulching appears to be the best way that anyone has found so far to bring in local briars and weeds and blend the roadsides into the natural landscape and at the same time to provide the necessary soil stabilization. Simple and inexpensive roadbank stabilization boils down to just one thing, how to get some kind of vegetation established on the bank that will hold the soil in place and not be a nuisance.



As a minimum requirement for roadbank stabilization the use of mulches for dry and infertile banks, as previously recommended by the Station, has proved successful on extensive projects.<sup>1/</sup> The procedure appears to be the most simple and inexpensive known today. Best results have been obtained on slopes of less than 1-1, and on banks that have been loosened with a pick at the time of sloping. Where the terrain does not permit lesser slope, mulches have been applied to slopes steeper than 1-1 with better results than obtained by any other feasible method. Elaborate landscaping methods, such as covering the bank with transplanted sod strips, can be made effective but the cost is prohibitive for general use.

Some project superintendents have not used mulches because of the appearance of weed straw, litter, and other debris on the banks for the first year or two, and because of the belief that the fire hazard along the road would be greatly increased. It is true that mulches may create a fire hazard for a time if they are applied as loose, bulky material, but when applied so that they will lie close to the ground, the mulches decompose rapidly to a stage where they are unimportant as a fire hazard.

Mulches may be applied in many ways and no attempt should be made to write rigid specifications because each roadbank may call for some slight modification of the procedure. However, to help establish the principles concerned, some general suggestions have been outlined on the following pages. Experience has shown that specific recommendations generally have to be made for each job depending on local conditions and source of material. Two general methods of mulch application may be outlined, based on the nature of the mulching material available: (1) staked weed mulches, and (2) staked brush and litter mulches.

The staked weed mulches are used in open country and wherever weeds can be obtained readily. They are generally more easy to apply than the staked brush and litter mulches that are used in heavily forested areas where weeds are not available. Both practices have proved to be feasible on extensive projects, and wherever the work has been done carefully both methods have given satisfactory stabilization.

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<sup>1/</sup> The first report by the Station on this subject was issued March 7, 1935 (Technical Note No. 12) and another was issued September 15, 1938 (Technical Note No. 31).



## Staked Weed Mulches

### Materials

(a) Small stakes 18-24 inches long and about 2 inches in diameter. The use of straight-grained, easily sharpened wood, such as dead chestnut, saves time in preparing stakes.

(b) Coarse weeds, briars, grass, meadow hay, or similar material. Straw from wild growth is preferable to clean fresh grain straw since it is easier to keep in place and carries more natural seed.

### Procedure

This is a general method for long and difficult steep banks, but it can be modified to suit any condition. The purpose of the stakes is to prevent the mulch from slipping down the slope and from being blown about by wind. On low slopes the stakes may not be required, provided the weed straw has a tendency to mat together. Frequently stakes are needed only on the upper portion of the banks. Sometimes only the bottom row is required, with occasional groups of stakes on the steeper and most difficult portions of the bank. This is a detail that has to be settled on the job. The best way is to try putting some of the mulching material on the banks and see if it will stay, remembering that the mulch will dry out quickly and may blow off when dry.

On a long steep slope one row of stakes, set 12 inches apart, is driven at the bottom of the bank just high enough up the slope not to be disturbed by road machinery. Additional stakes are driven either at random or more or less uniformly over the entire bank, the exact spacing to be governed by the nature of the mulch material to be used and the steepness of the different portions of the bank. Six inches of the stake should be left above the ground.

Coarse weed straw, briars, or long grass straw is cut with Council tools and scythes. This material is laid by hand to reach between the stakes and form a continuous framework to a depth of not more than 2 to 4 inches, depending on the nature of the material. Too heavy mulching of fine debris may cause composting and kill any seed present. The litter must be sufficiently thick to prevent movement of the soil, but should not interfere with germination and establishment of natural vegetation. This mulching method is applicable to banks on which enough soil is present for stakes to be driven in with little difficulty. Exposed banks of rotten granite can be improved in appearance by mulching the upper soil horizons on the top of the banks to obtain such natural vegetation as will come in, and by planting to trailing plant species, but it is not feasible to mulch



rocky banks completely. In the southeast, banks of deeply weathered granites frequently slough and erode as do soil banks. Where this is the case, the banks are treated in the same manner as the soil banks.

On many extensive field tests weeds have been cut and applied to the banks in the early fall. Some seed germination of perennials and biennials took place at once. By spring the mulch was settled in place by the winter rains, and seedlings of annual species began to appear. The banks were well covered with vegetation by the end of June.

Decomposition of the litter after it has been compacted by rains takes place quite rapidly, the litter becoming inconspicuous in less than one year after application. An examination of the soil beneath the mulch after this time shows that there has been mixing with the organic material from the mulch and a general improvement for plant growth in the surface soil on the bank.

Sloughing from frost action and erosion by heavy rains is completely arrested as soon as the mulch is applied. This accounts for the more rapid improvement of the surface soil on banks under a mulch than on unstabilized banks.

The following list, based on the use of a 20-man crew, will serve as a general guide to equipment and organization for applying staked weed mulches.

#### Labor Requirements

5 Men to make stakes	2 Men to load mulch
4 Men to set stakes	1 Man to drive truck
5 Men to cut mulch	2 Men to unload and spread mulch
1 Man to rake mulch	

#### Equipment

4 "Men Working" signs	1 Tool box
5 Pitch forks .	6 Mill files with handles
2 Scythes and stones	2 Ladders
8 Council tools	4 Safety belts and ropes
3 Swamping axes	2 Wooden pulleys, 1/2-inch
2 Falling axes	200 Feet 1/2-inch rope
3 Hatchets or small axes	1 1-1/2-ton stake body truck
2 Crosscut saws	1 1-1/2-ton pickup truck
10 Leather gauntlets	1 Horse mower (if needed)
5 10-lb. mauls	1 Dump rake (if needed)
5 2-lb. stonecutter's hammers	



## Brush and Litter Mulches

On many roads through forested areas weed material for mulches may be entirely absent and it is necessary to make use of some other suitable materials that are close at hand. The chief requirements are that the mulch will lie close to the bank, decompose rapidly, and furnish seed of local plant species to grow and hold the bank permanently.

Banks have been stabilized by simply placing brush or small limbs from cull trees on the slopes. When large trees are close by the brush will catch the leaf fall and gradually accumulate a satisfactory mulch. The next procedure is to rake the litter from the forest floor on to the bank and to hold it in place with tree limbs and poles placed in some systematic manner. This has led to the use of staked brush and litter mulches of different kinds. Tests over several years prove that the systematic application of the brush and litter gives far better results than simply throwing the mulch on the bank. The following method has been successful.

### Materials

- (a) Stakes as described for weed mulches.
- (b) Duff and litter from forest floor; limbs from small cull trees.

### Procedure

The object is to get 4-5 inches of woods litter on the bank and to hold it there until it has a chance to improve growing conditions. The procedure may be modified to suit the location. One practice may be listed in five steps.

1. Stakes are set as described for weed mulches.
2. A low wattle is constructed on the contour row at the bottom of the slope. Very small flat brush is hung downward from pegs to form a very light framework over the entire bank. All this brush must be less than one inch in diameter.
3. Duff and litter collected with Council tools from the forest floor above are raked down over the bank. A uniform covering about four inches deep will be satisfactory in most cases.
4. A second layer of light brush is placed over the litter layer, if the duff and litter are such that they can be moved by wind or rain.
5. The poles from which the limbs have been cut to obtain the



light brush are laid horizontally on the bank, and cross staked if necessary to bring the entire mulch as close to the bank as possible.

In cases where the litter has wind-blown from the forest floor above the bank, it can be obtained more conveniently from accumulations in accessible ravines. Pine litter and mixtures of pine and hardwood litter will hold on steep banks more readily than will hardwood litter alone.

Council tools have been found to be most effective in raking up the litter and cutting into the duff to bring weed seed from the forest floor to the bank. Where stones are present on the forest floor above the bank, the raking will start rocks moving. For safety, bank operations must be suspended during the raking.

The flat brush can be trimmed from the limbs by using pruning knives, machetes, light axes, or knives. Heavy bowie knives are less dangerous in the hands of unskilled workers than are machetes. The foreman in charge should consult with superiors and inform workers where to obtain brush and what species are to be cut in order to protect timber and ornamental values along the roadway.

One-half inch ropes and pulleys have been used advantageously to pull material up high steep banks. For the men working on long dangerous slopes, homemade safety belts have been used.

The following lists, based on the use of a 20-man crew, will serve as a general guide to equipment and organization for applying brush and litter mulches:

#### Labor Requirements

4 Men to make stakes	2 Men to trim brush
2 Men to set stakes	2 Men to lay brush
2 Men to cut brush	8 Men to rake litter

#### Equipment

4 "Men Working" signs	5 2-lb. stonecutter's hammers
8 Council tools	1 Tool box
5 Pitch forks	2 Ladders
5 Light axes	6 Mill files with handles
2 Falling axes	4 Safety belts and ropes
5 Pruners, knives or machetes	2 Wooden pulleys, 1/2-inch
2 Crosscut saws	200 Feet 1/2-inch rope
5 10-lb. mauls	1 1-ton stake body truck





One-half inch holes and 1/2 inch holes have been made in the soil at intervals of 10 feet. The soil is very hard and the holes are very deep. The holes are made with a 1/2 inch drill bit.



The following data, based on the use of a 1/2 inch drill bit, will show the results of the test.



Setting stakes on the bank is the first step in applying a weed mulch. Stakes prevent mulches from being blown about by wind. They are set on the loosened bank with a two-pound hammer and driven with a heavy maul.

Weeds and briars cut in the early autumn make ideal mulching material. The upper workman is bringing mulch to the bank with a pitchfork. The lower workman is placing a framework of tall weeds around the stakes by hand.



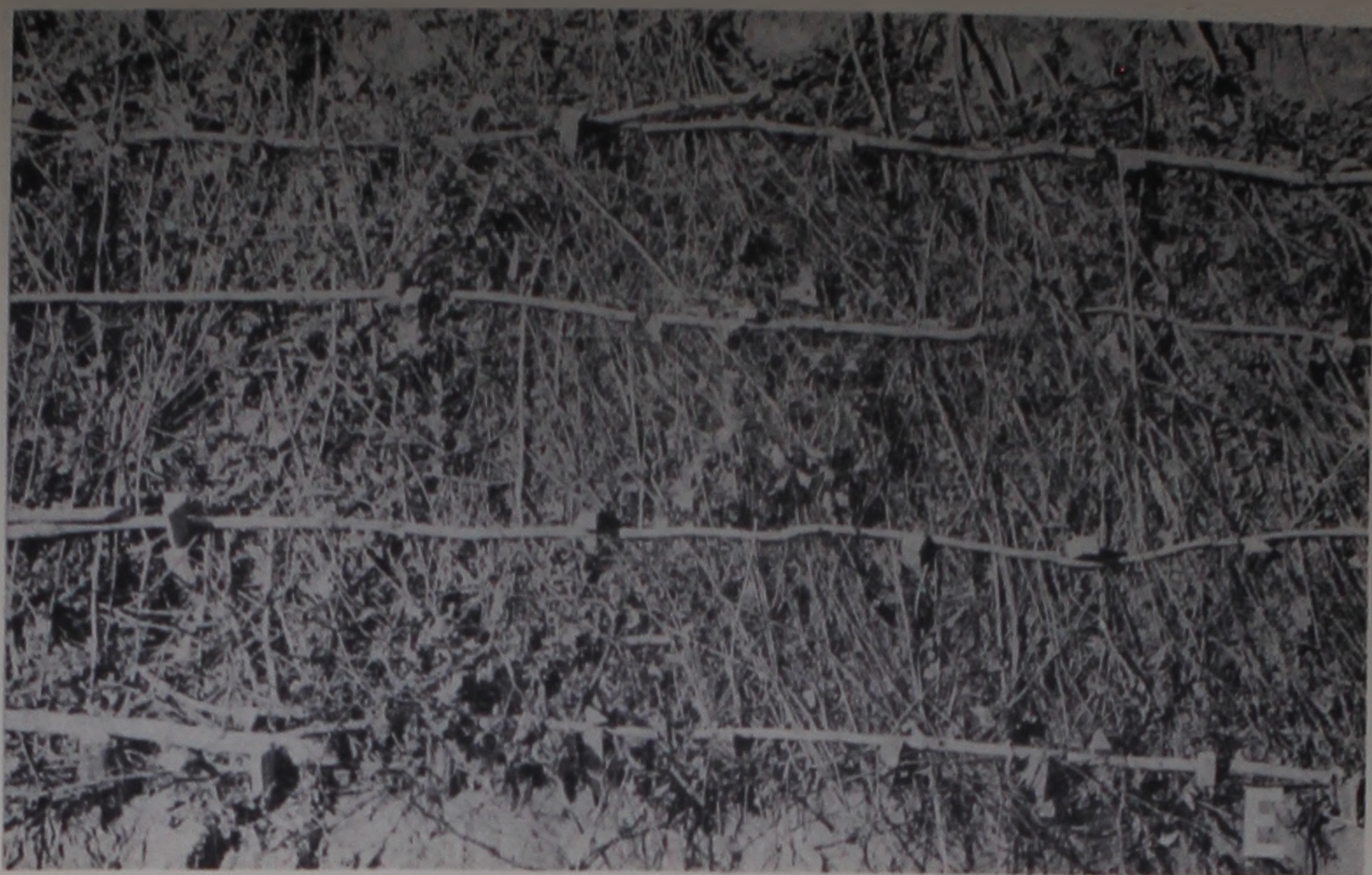




A newly sloped bank, stabilized with a weed mulch in September. Seedlings of fall germinating species appeared at once. Annual species germinated in May. After several rains the mulch settled and became compacted close to the ground where decomposition proceeded actively.

By the following June the fall mulched bank became green with natural vegetation. The mulch lay close to the ground and became inconspicuous after two years.







A well laid litter and brush mulch on a steep bank. The woods litter raked on to the bank is held down by small brush which in turn is held down by cross staked poles.

A well loosened bank receiving a topsoil dressing from stock piles made at the time of highway construction. The bank will be seeded and lightly mulched with straw. Successful stabilization is assured.







Transplanting root clumps to a steep bank results in many failures to obtain stabilization. Such losses can be prevented by mulching the bank at the time of planting. This bank along a national highway was left too steep for rapid stabilization. It should be given a lower slope, and the surface left in a loose condition.

Mulches generally need some mechanical aid to help them stay in place on steep banks. This mulch slid down the bank and was blown about by the wind. A few stakes would have prevented movement of the mulch. This bank should have been sloped more, and the top shoulder rounded off.



## PROCEDURES FOR BETTER ROADBANK STABILIZATION

### Preparation of Banks

Frequently newly sloped banks are left too smooth to favor vegetation establishment. Slopes smoothed to mechanical precision are apparently considered good engineering by the crews doing the work. Such banks suffer from frost heaving and subsequently erode as quickly as unworked banks. Experience has shown that smoothed banks, particularly if composed of stiff compact soils, should be loosened with a pick to favor vegetation establishment.

On many projects the road engineers now leave the banks rough or loosen the entire bank by lifting the soil with a pick but leaving the clods in place. This should be done before the top shoulder is rounded so that the fertile soil will be caught between the clods on the roughened bank.

Frequently on rounding off the top shoulder the surface is left much too smooth. Here again a rough surface is preferable. On moderate slopes it is possible to dig up and pulverize the top shoulder so that it may be raked back and forth to give the desired radius, but the soil, with the exception of that caught on the roughened bank below, should be left more or less in place.

### Seeding

Whether or not seeding mulched banks is necessary depends on the amount of natural seed carried to the bank with the mulch. Weeds cut in the fall usually will have plenty of seed, while those cut in the spring may have almost no seed at all. In any case, it is frequently desirable to seed in some grasses to augment and supplement other vegetation. Different grasses require somewhat different sites; so a mixture is best if the seed is to be used for a large project. For the portion of the Southern Appalachian region above the range of Bermuda grass, the species that have been generally successful are rye-grass, orchard-grass, and red-top, with a small amount of the blue grass to come along and form a sod if the site proves satisfactory. The grass mixtures should be applied at the rate of 20-30 pounds per acre. Grasses can be seeded right on the mulch, preferably during a rainy period.

Of the legumes, both annual and perennial lespedezas have been successful. The seed for the annuals is generally easier to



obtain and cheaper than for the perennials. They are more shallow-rooted than the perennial species, but they do produce a fast growth the first season and respond well to fertilizers. They are supposed to reseed themselves well, and, if the surface of the bank is protected with a mulch, they generally do. However, where the perennial lespedeza (L. serica or other species) has been used, it has been more permanent for stabilization than have the annual species.

White clover is a good species to put into a seed mixture for broadcasting on shoulders and fills, but most of the clovers require some lime. Shoulders and fills have been seeded without mulching but a heavy rain soon after the job is done will frequently wash out the seed and cause all the work to be lost.

Fall-sown winter rye serves as a good nurse crop for grasses on fills, and will prevent the erosion damage that would otherwise occur during winter.

In most localities an abundance of suitable grass and weed seed for bank stabilization can be collected in the fall at little cost, and on extensive road projects this procedure is recommended.

### Transplanting

When roadbank stabilization became popular a few years ago, a great deal of transplanted material was used. The favored species were honeysuckle, coralberry, privet, ground myrtle, rose and kudzu. Under exactly the right conditions all of these species have come through successfully and produced good results in holding the bank without the aid of mulching or any other mechanical device. The fact that root clumps of honeysuckle and similar species can be successfully transplanted only under certain favorable conditions was overlooked and hundreds of miles of planting was done at a tremendous cost, with practically nothing to show for the expenditure. There is nothing wrong with transplanting as a method. In fact it is to be recommended as the desirable procedure for getting woody plants on the banks quickly. The mistake lies in not providing more favorable growing conditions. A study of extensive failures shows that soil instability around the clumps and insufficient moisture have been the essential reasons for failure. Where these two unfavorable conditions have been corrected by mulching, many miles of root clump planting have been successfully salvaged. The obvious conclusion is that on most banks all transplanted material should be protected by mulches to furnish better growing conditions. The mulching should be done at the same time as the planting.



### Topsoil Dressings

Pulling part of the top shoulder soil, which is generally more fertile, over the roughened bank below is a good method of topsoil dressing. This procedure can be carried out further, even by hauling rich topsoil to the banks from a distance. This is a commendable practice although it may become expensive.

On new locations where cuts are to be encountered, experienced road engineers now push the topsoil to one side in stock piles. They then draw upon these piles for topsoil dressings for banks, shoulders, etc. The banks are then seeded, and mulched lightly. By accumulating frequent stock piles the hauling distance is reduced to a minimum. This practice is particularly important in highly developed farming areas where topsoil is generally not taken from the top of the bank. In less settled areas there is generally sufficient topsoil available above the slope.

One practice is to throw topsoil over the mulch to keep it in place. Occasionally this practice works well enough, but frequently topsoil thrown on top of a moderately heavy mulch will result in clods drying on the surface, or in seedlings starting on top of the mulch and being killed by desiccation later. In general it is better to get the topsoil under the mulch, or to have them thoroughly intermixed.

Where frost action and erosion are not to be considered, successful bank stabilization has been obtained by loosening the banks with a mattock, applying a light topsoil dressing, and seeding to grass mixtures directly without the use of mulches of any kind. Nevertheless, to safeguard seedlings from being washed out by heavy rain before they are established, a mulch placed on the topsoil dressing is always a worthwhile insurance. At the same time a mulch will prevent seedlings from being killed by rapid desiccation of the bank during summer droughts. Frequently an excellent stand of grass is obtained with a topsoil dressing applied in the spring and summer months. The grass makes a fine appearance during the first growing season, only to be easily killed and thrown out by heavy freezes during the winter months. Consequently, although topsoil dressings are valuable in vegetation establishment on roadbanks, they do not serve the same purpose as mulches.

### Fertilizing Mulched Banks

The judicious use of a light application of a complete fertilizer has been found useful in helping the growth of natural vegetation on sterile banks. Fertilizer may be very effective one to two years after mulching to increase the amount of growth present.



Too heavy an application of fertilizer is harmful on dry sites or even on average moist sites when the weather turns off dry for a few weeks. Consequently it pays to use about 400 or 500 pounds to an acre of bank, with a 4-8-4 fertilizer or its equivalent. Other fertilizers are useful but they are harder to apply in the right amounts. Tests with various kinds of fertilizers are being tried out in different localities but the results to date have not brought out any advantage of other fertilizers over a regular complete fertilizer which can always be obtained at local stores.

Light applications of fertilizers can be made at any time of year but fertilizer should not be applied when the ground is particularly dry. In general, if only one application of fertilizer is to be used, it should be made in the late spring. The fertilizer can be applied on top of the mulch since the first rain will carry the nutrients into the soil. It may be put on directly by hand or with a cyclone hand seeder. In most cases it is applied by hand without the aid of mechanical devices.

The use of lime, preferably as fine ground limestone, has shown good results with some species, but it is heavy to haul and greatly increases stabilization costs. Many road engineers prefer to depend on local vegetation that is able to grow under the existing conditions rather than try to use lime to obtain a growth of some species not commonly present.

### COSTS

The cost of applying mulches to roadbanks differs so much, depending upon the ease of obtaining suitable materials, that only general estimates can be given. On extensive projects where the crews are well organized costs have averaged as low as ten cents per square yard, including the necessary sloping and rounding the top shoulder.

A tremendous amount of hand sloping prior to stabilization has been required on old construction where the cut banks have been left too steep. The cost of this hand sloping is being avoided by cutting the bank to the suitable slope by machinery.

The costs of practical methods of roadbank stabilization such as those described in the preceding report, are returned by reduced maintenance alone, frequently within a single year. However, the expenditure for stabilization also pays increasing dividends in improved roadside appearance, in prevention of stream silting and in fewer accidents due to cars skidding on clay washed on to the highway. Roadbank stabilization costs amount to only a small fraction of the entire road investment. No road construction can be considered as finished until bank stabilization has been effected.



## SUGGESTIONS FOR IMPROVEMENT OF MULCHING PRACTICES

In the past year several hundred miles of roadbanks have been treated by the mulch method and the following suggestions are submitted as a result of this experience.

Round off the tops of slopes and leave the banks fairly rough so that they will catch seeds and hold moisture. Pulverize the top of the shoulder and rake the soil over the loosened banks. Don't "manicure" a slope until it is glassy smooth.

Mulch the bank before it has had time to dry out. Vegetation will get off to a better start if the job is so organized that mulch is on hand and ready to apply as soon as the sloping is finished.

Pegs are not needed on gentle slopes if a mulching material that will mat and hang together is used. Fall-cut weeds generally do this.

The best results are obtained when weed and grass mulches are applied in the fall when the seed are ripening. Weeds cut and applied in the winter and spring do not contain as many seeds, and for this reason results are not obtained as quickly. Weeds can be cut in the fall, cured, and dry-stacked like hay for use several months later.

Straw from small grain can be used if weeds are not available. In most localities there are always a few stacks that can be had for the hauling, or at most for a few dollars. Weeds, however, usually are easier to put on and give the best results; they are enough better to justify hauling them 5 or 10 miles if necessary.

Loose leaf litter raked down from adjoining stands of timber is only fairly satisfactory as a mulching material. It goes on best when the leaves are wet but even on flat slopes it must be covered with brush weights to prevent blowing off when the leaves dry out.

Don't expect to get an inexpensive job if slopes are laboriously manicured and polished or if a fancy lattice-work of poles is pegged down over mulch that will stay on without such treatment. Surprisingly steep slopes have been reseeded successfully with weed mulches simply by draping long-stemmed weeds around pegs of the proper length. The mulching method need not be expensive but it will be unless there is adequate supervision and common sense.